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MEMORANDUM

To: Sergio Ruiz, Caltrans

From: Hugh Louch, Dara O'Byrne, Alta Planning + Design

Date: September 19, 2017

Re: District 4 Bicycle Needs Analysis Summary

Introduction

Caltrans District 4 serves the nine county Bay Area, including Sonoma, Napa, Solano, Marin, San Francisco, Contra Costa, Alameda, San Mateo and Santa Clara counties. As a part of the Caltrans District 4 Bicycle Plan, a needs analysis was performed to better understand the needs for bicycle transportation improvements on the state transportation system.

Summary of Approach

The overall goals of the needs analysis include:

- Identifying where the state transportation network serves bicyclists and where it does not
- Identifying how the state transportation network complements local and regional bicycle networks – the state transportation system is not the primary network for most bicycle travel, but can significantly impact the safety and comfort of that network
- Prioritize needs on and across the state network

The flow chart below depicts the basic process for conducting the needs assessment. Two general considerations shape the needs analysis - crossing the state highway system and traveling along state highway routes. The analysis recognizes that projects will be defined differently for access controlled routes (e.g., freeways) and conventional, surface highways that have many points of access. For each of these situations, the analysis looks at four factors – safety, demand, supply (quality of the network or crossing) and input from the public.

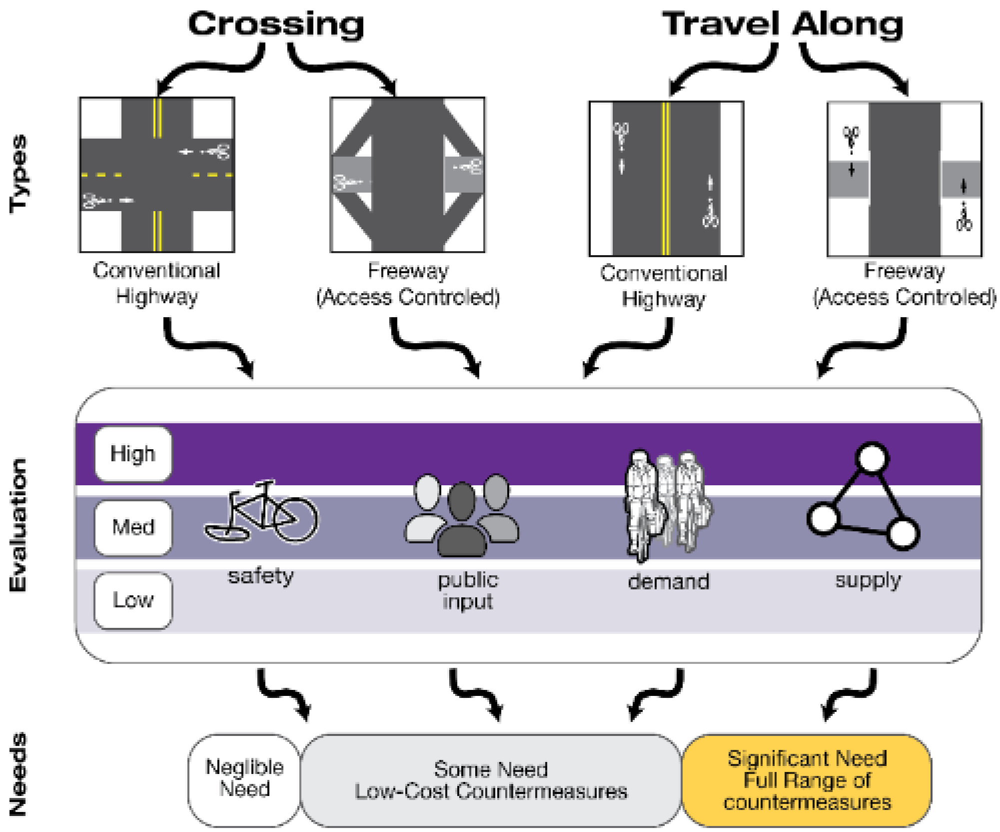
Ultimately, the objective of the needs analysis is to sort the entire state highway system into three broad categories:

- **High needs requiring unique projects**. These areas will yield highway improvements that require a unique, bicycle-focused project. These may include relatively low-cost signage and striping improvements, but are more likely to include new separate crossing, separated bikeways, major interchange or intersection improvements and other significant improvements
- **Typical needs to be integrated into other improvements**. Because bicyclists can access most of the state transportation system and following Caltrans Complete Streets policy (Deputy Directive 64, Revision 2), much of the state transportation system will have 'typical' needs that can be incorporated into regular maintenance, resurfacing, and similar types of improvements. These projects are typically funded through the State Highway Operations and Preservation Program

(SHOPP) and low-cost countermeasures that can be incorporated into these projects are appropriate.

- **Limited or no needs**. A small portion of the state transportation system may either provide reasonable accommodation for bicyclists currently or have limited need defined.

Figure 1 Needs Analysis Approach



As the process evolved for developing needs, two basic concerns emerged that shaped how the needs analysis was conducted. At its simplest level, the need for a bicycle facility on or across the state transportation system required meeting two conditions:

- **Significant demand for or current use of the system** – do a significant number of bicyclists currently use/cross or desire to use/cross a specific location of the state highway system?
- **Presence of a significant safety concern, challenge, or barrier** – have bicyclists experienced high numbers (or severity) of collisions or do they avoid using or crossing the system due to perceived challenges?

We gathered both direct and indirect measures to answer each of these questions using four primary data sources:

- Demand - the Metropolitan Transportation Commission (MTC) travel demand model provided an indirect measure of potential bicycle trips
- Safety - the Statewide Integrated Traffic Records System (SWITRS) collects on traffic collisions that is used as a direct measure of safety.

- Supply/Connectivity - data from Caltrans on the state highway system and Open Street Maps (OSM) was used to identify the level of traffic stress of both the state highway system and crossings.
- Public Input - a survey was conducted as part of this project, to gather geographic information about bicycling needs.

Table 1 summarizes the data sources and measures used as part of this approach.

Table 1 - Summary of Needs Performance Measures

Data Source	Measure	Type*
Demand/System Use Measures		
MTC Model	Estimated likely bicycle trips	Indirect
Public Input	Locations of current network use/crossing (direct)	Direct
	Locations of desired network use/crossing	Direct
Safety/Challenge/Barrier Measures		
SWITRS	Existing bicycle collisions by severity	Direct
Caltrans/OSM Network data	Level of traffic stress	Indirect
Public Input	Locations where State highway system is a barrier	Direct

The remainder of this report provides details on the calculation of each of these measures by the four data sources used to calculate the measure.

MTC Demand

A key element in the identification of needs is that bicyclists currently travel along/across the state transportation system or would travel along/across the state transportation system if a facility were available. We use data from the Metropolitan Transportation Commission (MTC) travel demand model to identify the latent demand for bicycling on and across the state transportation network. “Latent demand” here is defined as trips that are currently made by any mode that could be made by bicycle.

Approach

The MTC model is a tour-based random utility model that predicts trips for the population of the 9-county Bay Area. Tour-based models consider each leg of the trip and the linkages between them when estimating the travel mode chosen. The MTC model predicts travel tours for the Bay Area for an “average workday”, based on statistical models developed using the California Household Travel Survey, demographic data on the region, and characteristics of the travel network. We use MTC’s predicted trips for the region to assess where bicycling-length trips are currently conducted.

For each predicted trip, the trip distance is evaluated using the shorter of the automobile and bicycle network distance skims. Both the bicycle and automobile network distances are considered to reflect the fact that, in some cases, automobile links are available that do not serve bicyclists, but could be retrofitted. To generate an estimate of bicycle trip potential, each trip is weighted based on the trip length, with the weights derived from the 2009 California Household Travel Survey (Figure 1).

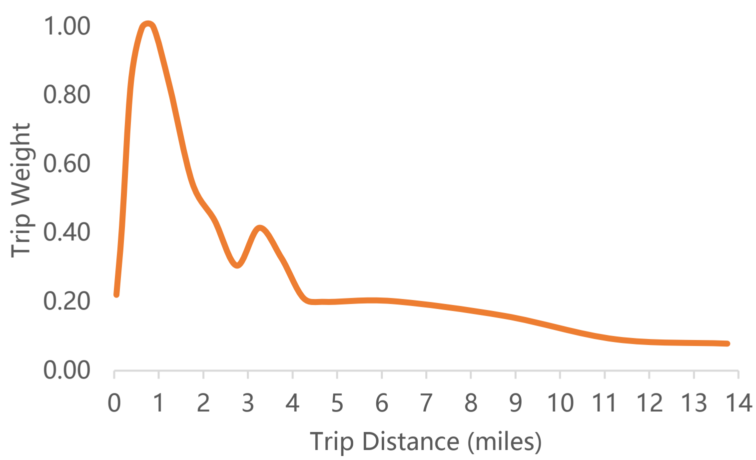


Figure 2 Bicycle Potential Trip Weight by Travel Distance

Trip weights are applied to reflect the fact that even if the bicycle network is improved, longer trips are less likely to be made by bicycle than short trips, with the exception that trips under a half or quarter mile would likely continue to be made by walking. These patterns could shift in the future with more longer trips made by bicycle, either as a result of improved route and end-of-trip infrastructure or wider uptake of technological advances such as e-bikes. However, in the interest of conservative estimation of benefits, current conditions are assumed.

For each origin and destination travel analysis zone (TAZ), we calculate the number of total weighted trips, yielding the relative weight associated with travel on each O-D corridor. A straight line is drawn connecting each origin and destination with a non-zero number of trips between them representing the shortest path that would be taken, and a buffer is generated at 20% of the length to account for out-of-direction travel that may be made by the cyclist to stay on the underlying network, and to access preferred route alternatives. A buffer is used here to represent travel patterns for two reasons: it does not presume that we know the routes that would be chosen by cyclists, and it allows us to consider demand at locations where bicyclists are not currently served by the system.

Figure 2 shows example demand polygons colored by their trip weights. Longer trips have larger zones of influence (width), but lower probability of travel by bicycle (lighter shading).

The final step in the demand evaluation aggregates the demand from each origin and destination, as many corridors can overlap with one another. Hexagonal binning is used (Figure 3). A grid of hexagons is defined in the vicinity of the state transportation network. For each hexagon, the trip totals for each of the intersecting demand polygons are summed to yield a total relative demand value across the network. The state highway facilities are then assigned demand values from the hexagons that they travel through.

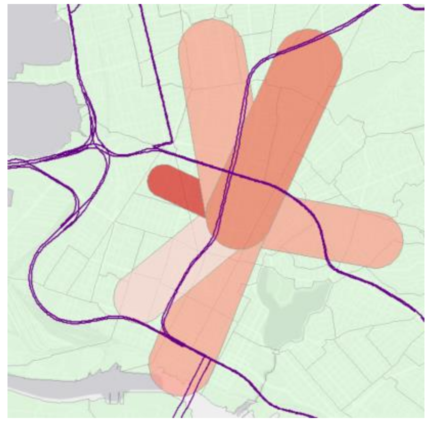


Figure 3 Demand Polygon Example (Oakland, CA)

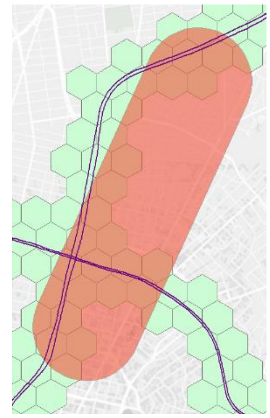


Figure 4 Hexagonal Binning Example

This approach provides an estimate of the level of latent demand for bicycling in the vicinity of each segment of the state transportation network. It is not intended to be an accurate representation of how many people will bicycle on or across the system, only a method to estimate

Scoring

Consistent with each of the measures, a four-point scale was created for the demand analysis to represent the level of demand on the state transportation system, using the thresholds identified in Table 2.

Table 2 Demand Thresholds for Needs Scoring

Score	Description
0	Bicycling not permitted or no potential demand
1	Rural roads between towns Fewer than 100 potential trips
2	Rural and small urban areas with low levels of development Expect 100 to several hundred potential trips
3	Small towns and more urbanized areas but not downtowns Expect several hundred to 1,000 potential trips
4	Downtowns, dense areas, many short trips Expect more than 1,000 potential trips

Results

The results for demand, safety, and supply were combined and presented together as part of the public outreach conducted for the District 4 Bike Plan. Maps of these results can be found at the end of the Supply Section (Page 13).

Safety

Safety was evaluated as part of the needs analysis by examining current collisions for bicyclists on the state transportation system. This approach to incorporating safety into the needs analysis represents a direct measure of potential challenges that bicyclists may face using the state transportation system. It is complemented by other indirect measures that are intended to capture where bicyclists do not travel because of potential barriers or safety challenges.

Approach

The safety analysis was performed using 11 years of bicycle collision, from 2005 through 2015, obtained from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS) database. This database provides summary collision data from California Highway Patrol (CHP) reports of collisions on state highway routes. California Highway Patrol is the agency responsible for digital collection of collisions data on the state transportation system, with a reporting threshold of $500 or personal injury.

Collision data in the TASAS database are stored in a number of files; for this analysis, the collision data file contained an entry for every party to a bicycle collision in the eleven-year study period—5,626 entries for 2,914 collisions – the multiple entries represent the individual parties involved in each collision. Each entry in the collision data includes information about the collision and identifies the point on the roadway where it occurred, including the highway milepost location, location type of the collision (highway, ramp terminal intersection, or intersection), primary contributing factors, movements preceding the collision, direction of travel, weather, roadway conditions, influence of alcohol, collision type, types of vehicles or parties involved, and more.

The TASAS collision data includes the number of occupants killed and injured in each collision but does not detail the reported severity of injuries. This information was gathered from the CHP's online Statewide Integrated Traffic Records System (SWITRS) database. The SWITRS database contains records for each reported collision and includes the collision severity levels listed in Table 3. Before conducting the safety analysis, SWITRS collision records were matched to the records in the TASAS database using collision date, time of day, county location, and cited collision type.

Table 3: Collision Severity Levels

Collision Severity Level	Description
1	Fatal
2	Severe Injury
3	Injury - Other Visible
4	Injury - Complaint of Pain
5	Property Damage Only (PDO)

Source: SWITRS

The collision data also feature an attribute that describes the location type of each collision: highway, intersection, or ramp terminal intersection. This attribute was used to organize the 2,914 collisions into separate groups based on location (Table 4).

Table 4: Collisions by Location

Location	Collisions
Segment	1,287
Intersection	906
Ramp	721

A quality control review of collisions location coding was conducted. A sample of ramp terminal intersection and intersection collisions were coded at the correct location. Segment collisions were reviewed for collisions located within 250 feet of an intersection to determine if they were possibly miscoded. No systematic errors were found in the coding of locations.

Scoring

High-priority highway segments, ramps, and intersections were identified using a modified version of the Equivalent Property Damage Only (EPDO) network screening performance measure from the Highway Safety Manual (HSM). The EPDO performance measure assigns weighting factors to collisions by severity relative to property damage only (PDO) collisions. The initial analysis used an EPDO performance measure with the weighting factors provided by Caltrans' 2016 benefit-cost parameters (Cal-B/C). However, the Cal-B/C framework weighs a fatal collision more than 20 times more heavily than a collision involving a severe injury. To support display and communication of the needs analysis, each metric was placed into a four-point scale. Using the EPDO measure for this purpose would have resulted in a scale where most categories had only various numbers of fatalities, with all injuries, regardless of severity, coded into the lowest category. Table 5 presents the scaling chosen to better capture the relative severity of collisions.

Table 5 Location Tiers based on Collision Severity and Frequency

Priority Tier	Conditions
4	Location has at least one fatal collision or at least two severe injury collisions
3	Location has at least one severe injury collision or at least three “other visible injury” collisions
2	Location has at least one “other visible injury” collision or at least three “complaint of pain” collisions
1	Location has at least one “complaint of pain” collision
0	Location has exclusively property damage only collisions, no collisions, or bicyclists are not permitted

The scoring process was run for the full 11 years of data and subsequently rerun for the most recent five years of available data (2011-2015) to better account for recent roadway improvements and changes in bicycle collision patterns over time. The methodology to screen the three location types (ramp, intersection, segment) were as follows:

- **Ramp Methodology**. Reported ramp collisions were first coded by severity. The 721 ramp collisions were then organized by alignment and spatially joined to the nearest ramp on the same alignment in the network using ArcGIS, aggregating collision severity data at each ramp. The ramps were summarized using the scoring criteria presented in Table 6.
- **Intersection Methodology**. Reported intersection collisions were first coded by severity. Then the 906 intersection collisions were spatially joined to the nearest intersection using ArcGIS, aggregating collision severity data at each intersection. The intersections were then summarized using the scoring criteria presented in Table 6.
- **Highway Segment Methodology**. Reported segment collisions were first coded by severity. A Python script was run in ArcGIS to segment the highway network into one-mile segments using the HSM sliding window methodology. The sliding window methodology takes a window of a specified length and moves the "window" along each roadway from beginning to end in increments of a specified distance. A mile-long window with a half-mile increment was used for the purposes of the District 4 analysis. Consistent with the HSM guidelines, the mile-long window length represents a segment length appropriate to the macro scale regional analysis to help identify priority locations for further review. This methodology helps to identify the portions of roadways with the greatest potential for reduction of collision frequency and severity through safety improvements. Once the sub-portions of the roadway segments have been created (i.e., "window"), the script spatially joins associated collisions (including those at intersections) to the corridor segment. Similar to the ramp and intersection methodology above, the collisions are summarized to assign a priority tier as shown in Table 5.

Results

The results for safety, demand, and supply were combined and presented together as part of the public outreach conducted for the District 4 Bike Plan. Maps of these results can be found at the end of the Supply Section (Page 13).

Supply (Level of Traffic Stress)

To analyze the existing supply, a Level of Traffic Stress approach is used to quantify the amount of stress a bicyclist experiences on the state highway system and on crossings of the state highway system. Level of Traffic Stress presents an indirect measure of challenges and barriers, indicating parts of the state transportation system that do not appeal to a wide range of potential bicyclists.

Approach

Level of Traffic Stress (LTS) is a concept developed at the Mineta Institute of San Jose State University.[1] LTS is a new approach to evaluating bikeways that considers how different types of bicyclists use the transportation system. It provides a four-point scale from least stressful to most stressful. Table 6 summarizes the scale. Typically, higher speed and higher volume automobile traffic increase stress, while bikeways that increase separation lower stress.

Table 6 Level of Traffic Stress Scores

LTS Score	User Group*	Typical Network Examples
1	The level most children can tolerate	Off-street paths
2	The level that will be tolerated by the mainstream adult population. 'Interested, but concerned'.	Low speed, shared streets; bike lanes on low volume streets
3	The level tolerated by American cyclists who are 'enthused and confident' but still prefer having their own dedicated space for riding	Bike lanes on higher volume streets
4	a level tolerated only by those characterized as 'strong and fearless'	No facility provided

* User group definitions cited from Maaza C. Mekuria, Peter G. Furth, and Hilary Nixon, *Low-Stress Bicycling and Network Connectivity*, MTI Project 1005, May 2012 and linked to common user type terminology.

Several data sources were used to generate the LTS estimates for the District 4 plan, including:

- State highway database. These data include locations and characteristics for state highways and was the primary data source used to estimate LTS on the state highway system itself
- District 4 Bike Map. This data source identified existing bicycle facilities on and parallel to SHS.
- Open Street Map (OSM). OSM provides a comprehensive source of data for crossing opportunities and information about the local network.

Scoring

LTS was developed focused primarily on the primary travel way for bicyclists. A unique approach was used for the state transportation system, due to the unique characteristics of that system. LTS was coded for

[1] http://transweb.sjsu.edu/project/1005.html

three situations - segments, conventional highway intersections, and highway ramps. Color coding is used throughout this part of the memo to reflect a typical LTS color scheme.

Segment Level LTS Scoring

LTS was coded for highway segments where bicyclists are permitted. This excludes most of the access controlled system of freeways and expressways, though the few segments of this portion of the network that allow bicycles were captured (e.g., CA-24 permits bicyclists for a short segment between the Caldecott Tunnel and Orinda).

Table 7 presents LTS coding for urban bikeway segments. Table 8 presents LTS coding for all other segments (rural and urban) with mixed traffic. Table 9 presents the coding of parallel routes.

Table 7 LTS Score for Urban Bikeway Segments

Number of Lanes	Bike Lane	Shared Use Path
2	2	1
> 2	3	1

Table 8 LTS Score for Mixed Traffic and Shoulder Riding

Traffic Volume	Shoulder Width (Feet)		
	<2	2 -<4	>=4
<400	2	2	2
400 - 1500	3	2	2
1500 - 7000	4	3	2
> 7000	4	4	3

Adopted from the Oregon DOT Analysis Procedure Manual

Table 9 LTS Score for Parallel Segments

Facility Type	Shared	Bike Lane	Buffered Bike Lane
Shared use path	1	1	1
Local	2	2	2
Minor Collector	3	2	2

Facility Type	Shared	Bike Lane	Buffered Bike Lane
Major Collector	3	3	2
Arterials	4	3	3

Intersection LTS Scoring

Traditional LTS analysis focuses on signalization of the intersection to determine LTS, not considering the approach facilities or other features of the crossing. For the state highway system, with higher overall speeds, significant turning movements on to the network, and other high stress features, a new method was developed that considers both the crossing itself and the approach to the intersection. Table 10 presents the LTS coding for the intersection and Table 11 presents the LTS coding for the intersection approach. The worse of the two values is used to code the LTS of the crossing.

For the purposes of evaluating and identifying projects, additional features were considered including:

- Markings through the intersection to provide bike lane continuation
- Advanced intersection protection such as protected intersections.
- Use of roundabouts and accommodation of bicyclists at the roundabout

These improvements generally can create lower stress crossing, but do not generally existing in many locations currently. As such they were not coded into existing conditions.

Table 10   LTS Score for Intersection Crossing

	Total Lanes Crossed including Turn Lanes (#)	No Control	4-way stop	2-way stop	Cross Street 2-way stop	Signal
Median Width >= 6'	1-2	2	2	3	1	1
	3-4	3	2	3	2	2
	5+	4	3	4	3	3
Median Width < 6' or No Median	1-2	3	2	4	2	1
	3-4	3	3	4	3	2
	5+	4	4	4	4	3

** Cross street 2-way stop provides the LTS coding for the primary direction (not the street with the 2-way stop)*

Table 11   LTS Score for Intersection Approach

Through Lanes on Cross Street	No Right Turn Channel	Right Turn Channel
1-2	1	2

Through Lanes on Cross Street	No Right Turn Channel	Right Turn Channel
3+	3	4

Highway Ramp LTS Scoring

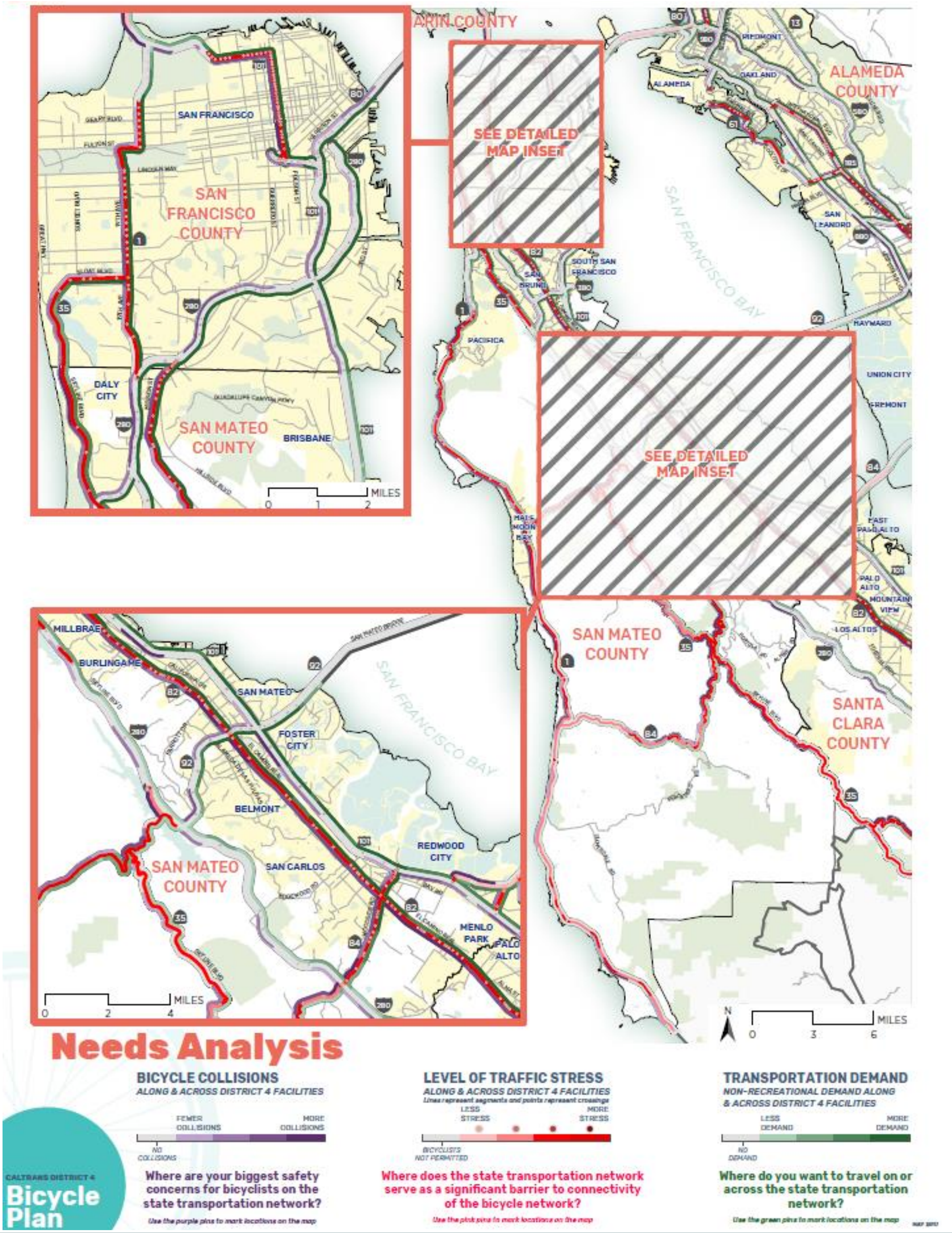
The third type of facility that was coded were the ramps to access controlled facilities. This coding combined information about crossing type and information about the highway ramps. Table X presents the coding, including coding of facilities that cross highways but do not have ramps. Given limited information, this coding relied on data from OSM to capture the functional classification and bike facilities on the crossing route.

Roadway Class of Crossing		No Ramps	Ramps With Signals	Ramps No Signals
Local	Bike Path	1	1	4
	Bike Lane	1	1	4
	No Bike Facility	1	2	4
Collector	Bike Path	1	1	4
	Bike Lane	1	2	4
	No Bike Facility	2	3	4
Minor Arterial	Bike Path	1	1	4
	Bike Lane	2	3	4
	No Bike Facility	3	4	4
Primary Arterial	Bike Path	1	2	4
	Bike Lane	3	4	4
	No Bike Facility	4	4	4

Note: bike path includes separated bikeways

Results

The results for supply, demand, and safety were combined and presented together as part of the public outreach conducted for the District 4 Bike Plan. Maps of these results are provided below, separately for four areas of the region.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Use the purple pins to mark locations on the map
LEVEL OF TRAFFIC STRESS
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Lines represent segments and points represent crossings
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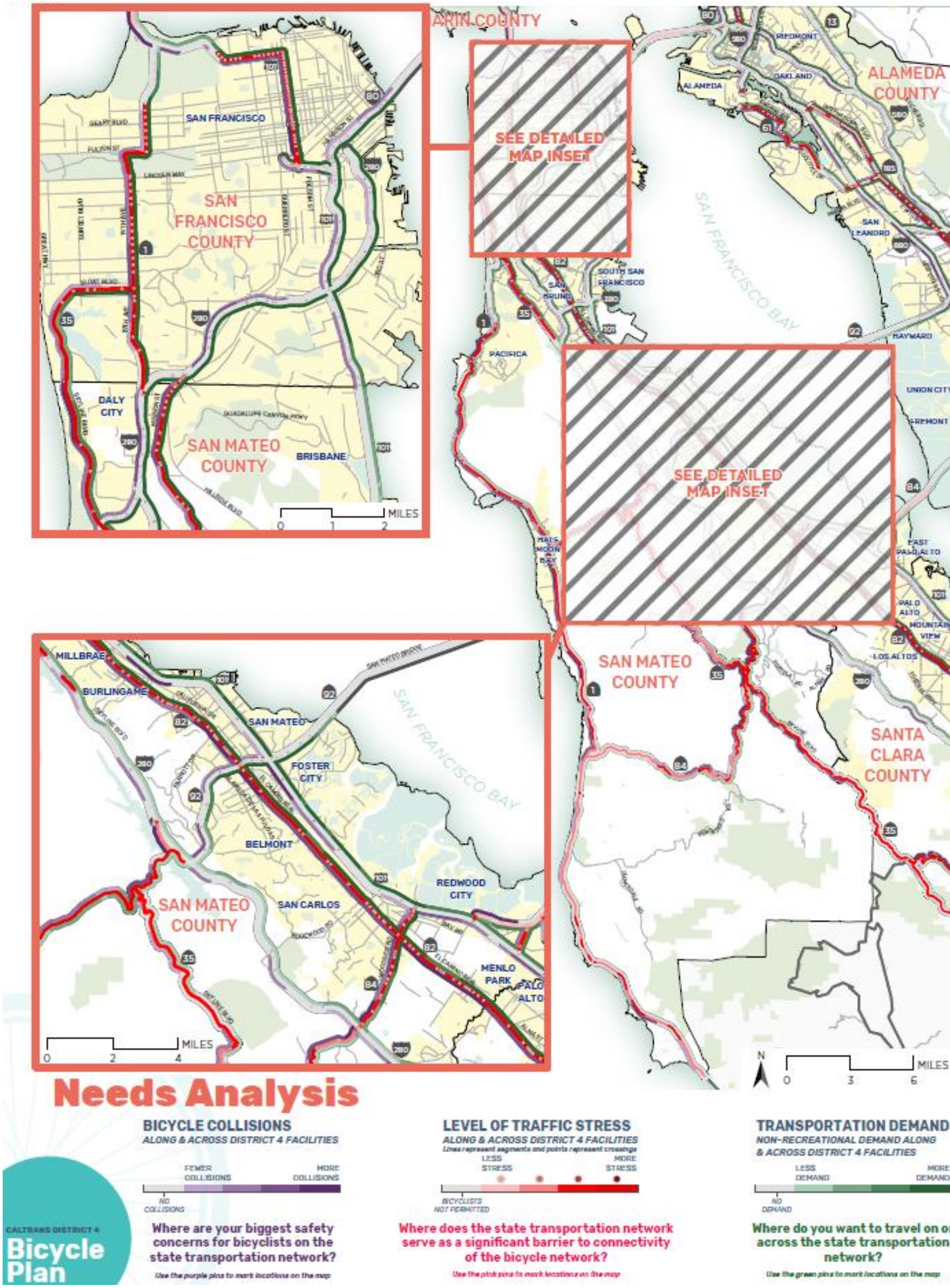

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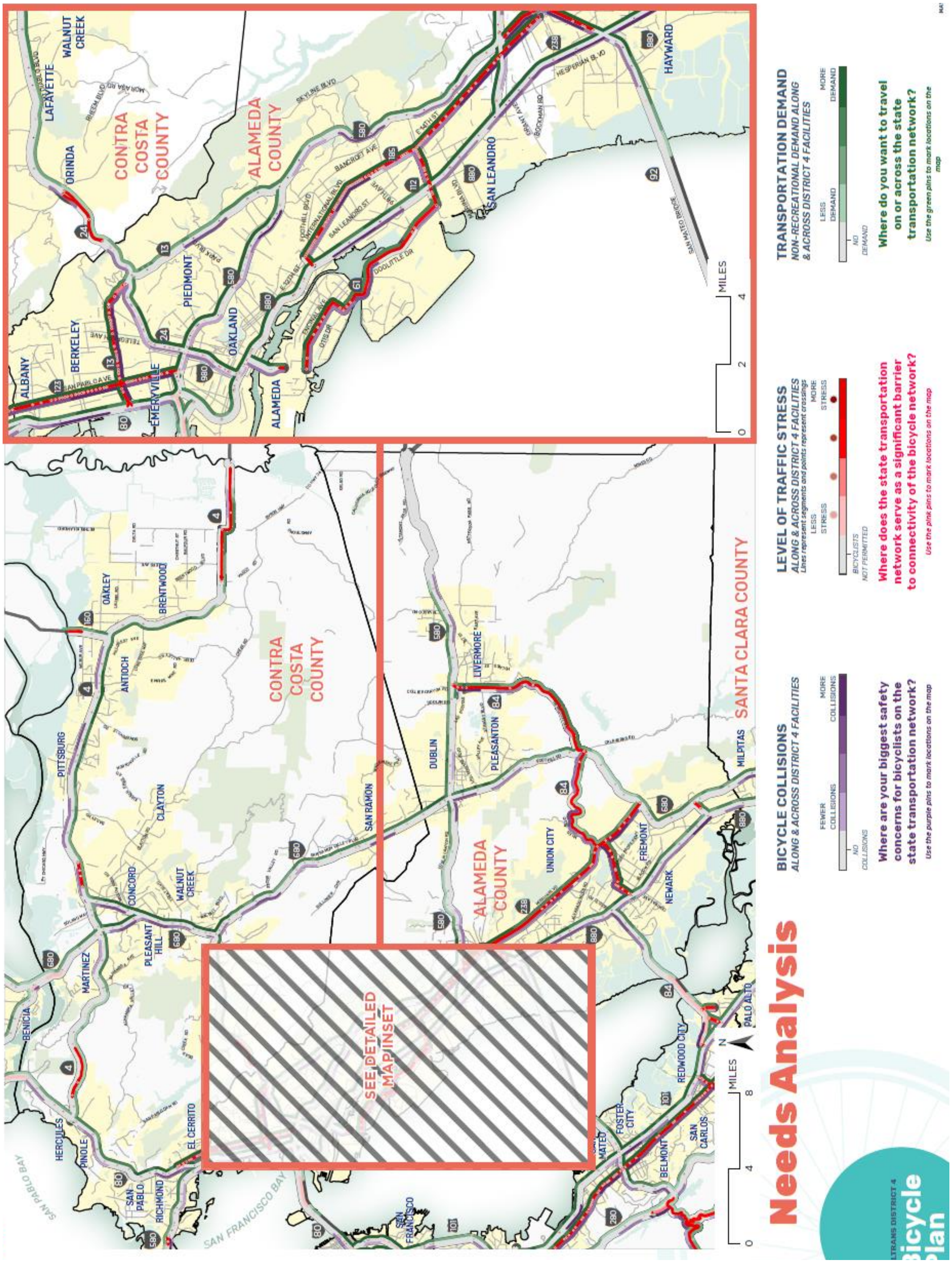
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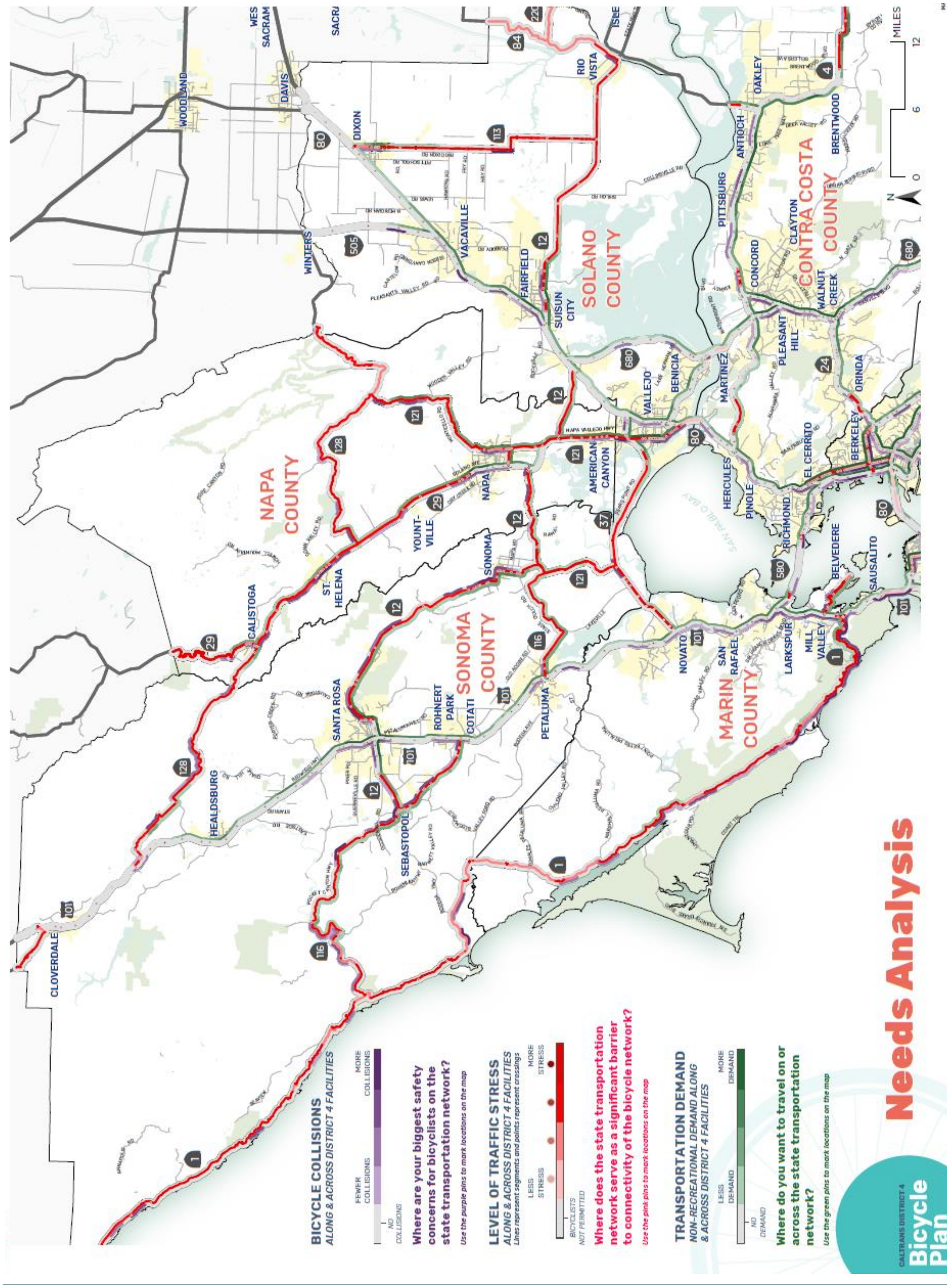
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CONTRA COSTA COUNTY
CLOVERDALE
HEALDSBURG
CALISTOGA
SANTA ROSA
SEBASTOPOL
ROHNERT PARK
COTATI
PETALUMA
ST. HELENA
YOUNTVILLE
NAPA
SONOMA
AMERICAN CANYON
VALLEJO
BENICIA
FAIRFIELD
SUISUN CITY
VACAVILLE
DIXON
WINTERS
DAVIS
WOODLAND
RIO VISTA
NOVATO
SAN RAFAEL
LARKSPUR
MILL VALLEY
BELVEDERE
SAUSALITO
RICHMOND
EL CERRITO
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Public Input

The first round of public outreach for the Caltrans District 4 Bike Plan, conducted in Spring and Summer of 2017, produced information about existing travel conditions for bicyclists on the state highway system, as well as information about desired improvements. Input was gathered through focus groups, workshops, and an on-line survey. For the purposes of the needs analysis, the on-line survey was used to generate direct measures of three primary concerns for the analysis:

- Where people currently use or cross the state transportation system – direct measure of system use
- Where people would like to use or cross the state transportation system – direct measure of system demand
- Where the state transportation system serves as a barrier to bicycle travel – direct measure of challenges and barriers

Approach

The online survey was administered to gather input on bicycle needs and issues across the Bay Area and recommendations to address existing barriers. The survey consisted of an interactive map and survey interface that allowed bicyclists and others to share their on-the-ground knowledge about mobility, barriers, and safety on and cross the state-owned transportation network. The survey was open between February and June 2017.

Over 4,700 people visited the survey website and nearly 3,500 completed at least one question in the survey. The interactive map was heavily used by survey respondents; over 20,000 “pins” were placed on the map, providing location-specific comments and feedback.

Location-specific input was gathered on five questions:

- Where do respondents currently bicycle along or across the state highway system
- Where would respondents like to bicycle along or across the state highway system
- What barriers do respondents face when bicycling along or across the state highway system?
- What bicycling improvements would respondents like to see made to the state highway system
- What existing bicycle facilities do respondents rate as high quality

The first three of these questions were used as input into the needs analysis. The latter two – about desired improvements and existing high-quality facilities – will be used in the identification and evaluation of projects but are not specifically pertinent to identifying needs.

For each of the first three questions, input that was received was associated with the nearest state highway segment. The survey data were coded onto the state highway network at quarter mile intervals. Points were aggregated to the closest quarter-mile segment. For the ‘where I bike’ and ‘where I would like to bike’ questions, points were aggregated separately for crossings and travel along. The survey specifically allowed respondents to indicate if they do or would like to use the state transportation network or cross the state transportation network. Survey points that were more than 250 feet away from the state highway system were excluded from the analysis.

Scoring

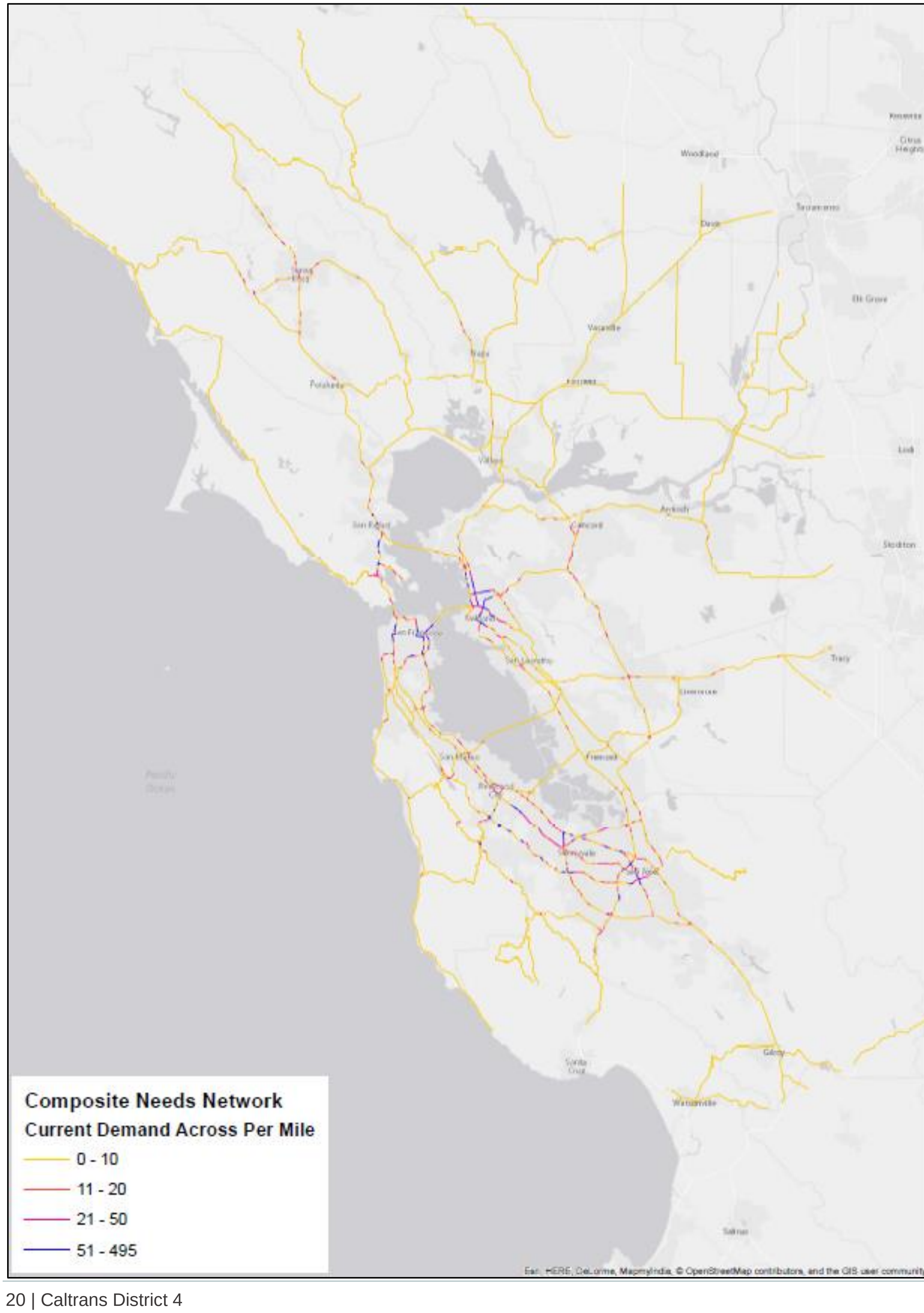
The survey points per mile we converted into a four-point scale to be consistent with the other measures generated through this process. Table x presents the scoring ranges used.

Table X Survey Point Density Thresholds for Needs Scoring

Score	Description
0	No survey responses
1	More than 6 points per mile
2	At least 6 but fewer than 12 points per mile
3	At least 12 but fewer than 24 points per mile
4	At least 24 points per mile

Results

The following five maps summarize the data that was generated based on this input. These maps use somewhat different ranges than the points per mile scoring


Composite Needs Network
Current Demand Across Per Mile
0 - 10
11 - 20
21 - 50
51 - 495
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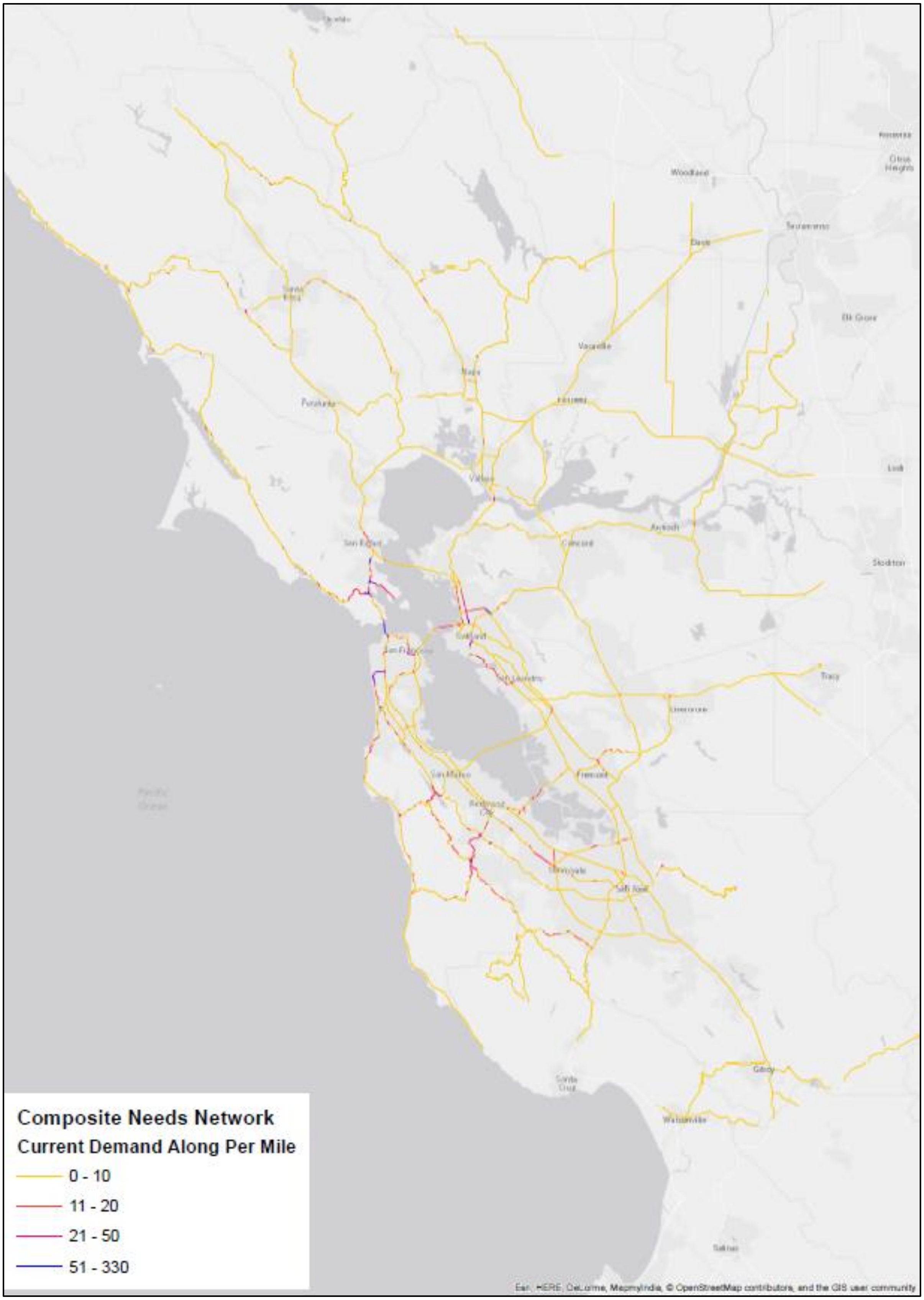
Composite Needs Network
Current Demand Along Per Mile
0 - 10
11 - 20
21 - 50
51 - 330
Woodland
Sacramento
Davis
Elk Grove
Vacaville
Napa
Petaluma
Vallejo
Lodi
Antioch
Concord
Stockton
San Rafael
Oakland
San Francisco
San Leandro
Tracy
Livermore
San Mateo
Fremont
Redwood City
Sunnyvale
San Jose
Gilroy
Santa Cruz
Watsonville
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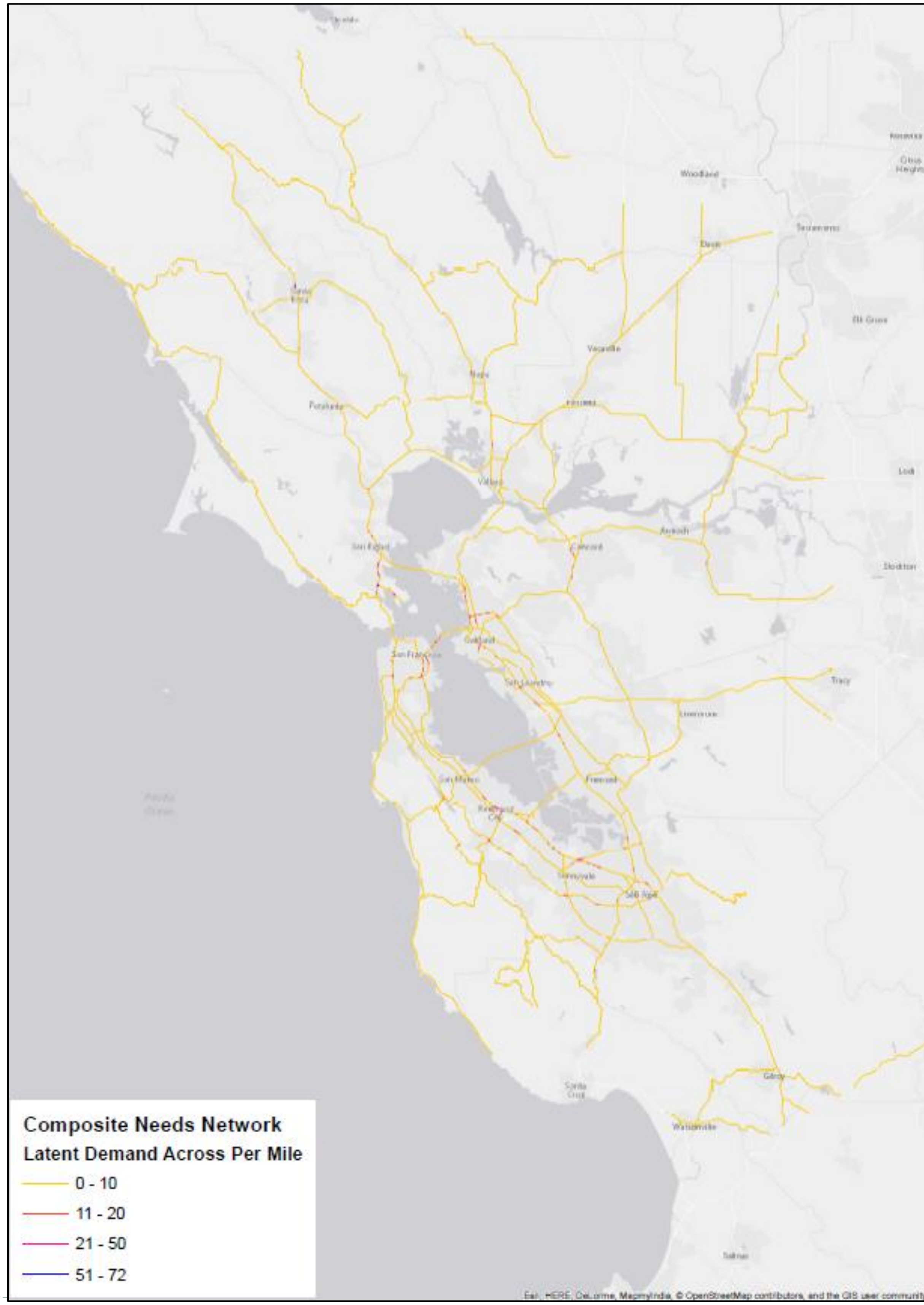
Composite Needs Network
Latent Demand Across Per Mile
0 - 10
11 - 20
21 - 50
51 - 72
Woodland
Davis
Sacramento
Elk Grove
Vacaville
Napa
Petaluma
Vallejo
Lodi
Antioch
San Rafael
Concord
Stockton
Oakland
San Francisco
San Leandro
Tracy
Livermore
San Mateo
Fremont
Redwood City
Sunnyvale
San Jose
Gilroy
Santa Cruz
Watsonville
Salinas
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Composite Needs Network
Latent Demand Along Per Mile
0 - 10
11 - 20
21 - 50
51 - 404
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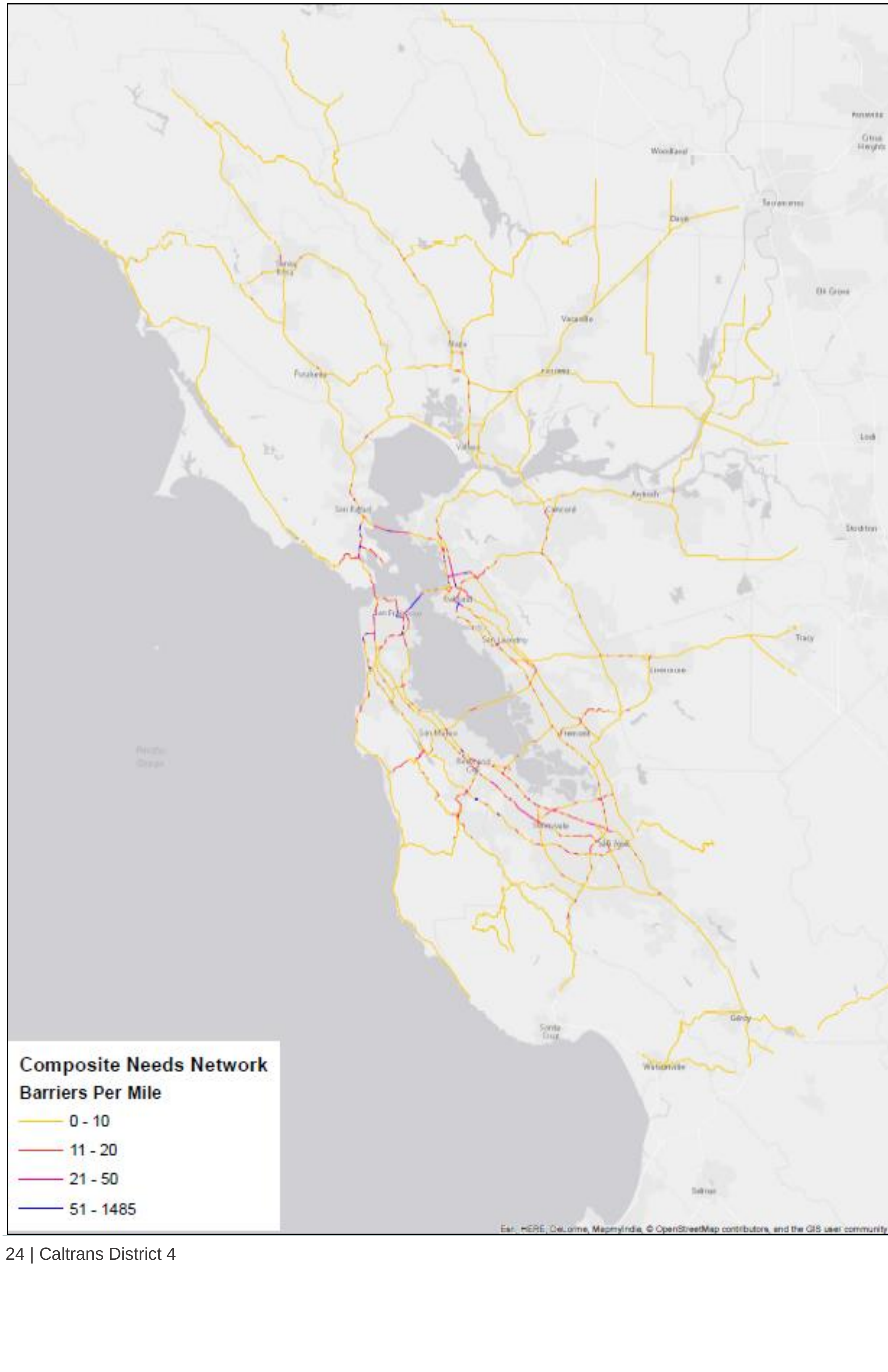
Composite Needs Network
Barriers Per Mile
0 - 10
11 - 20
21 - 50
51 - 1485
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